SOLAR/1014-79/02

Monthly Performance Report

HEI WAI WONG

FEBRUARY 1979

U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

MONTHLY PERFORMANCE REPORT

HEI WAI WONG

FEBRUARY 1979

I. SYSTEM DESCRIPTION

The Hei Wai Wong site is a four-story multifamily housing complex in Honolulu, Hawaii. Solar energy is used for preheating domestic hot water (DHW) and laundry service hot water. The solar energy system comprises three distinct, essentially identical systems, only one of which is instrumented for performance evaluation. The instrumented system supplies preheated hot water to six apartment units and to the laundry of the housing complex. The system has an array of flat-plate collectors with a gross area of 807 square feet. The array faces south at an angle of 24 degrees to the horizontal. Water is the transfer medium that delivers solar energy from the collector array to storage and to the hot water loads. Solar energy is stored on the roof in a 1230-gallon storage tank. When solar energy is insufficient to satisfy the hot water loads, auxiliary water heating for each apartment is provided by electrical heating elements in individual 30-gallon DHW tanks. Auxiliary heating of hot water in the laundry is provided by a gas heater in the 85-gallon hot water tank. The system, shown schematically in Figure 1, has two modes of solar operation.

Mode 1 - Collector-to-Storage: This mode activates when a sufficient temperature difference exists between the collector surface temperature and the bottom of storage to activate a thermosiphon flow between collector and storage. The flow continues as long as the temperature difference is great enough to maintain the effect.

Mode 2 - Storage-to-Load: This mode activates when there is a demand for hot water replenishment from either the individual DHW tanks or the laundry tank. The system is pressurized by the city water system.

II. PERFORMANCE EVALUATION

INTRODUCTION

The site was occupied during the month of February and the solar energy system operated continuously during the month. Solar energy satisfied 78 percent of the DHW requirements. The solar energy system provided electrical energy savings of 5.8 million Btu and fossil fuel energy savings of 3.8 million Btu.

WEATHER CONDITIONS

During the month, total incident solar energy on the collector array was 30.3 million Btu for a daily average of 1342 Btu per square foot. This was below the estimated average daily solar radiation for this geographical area during

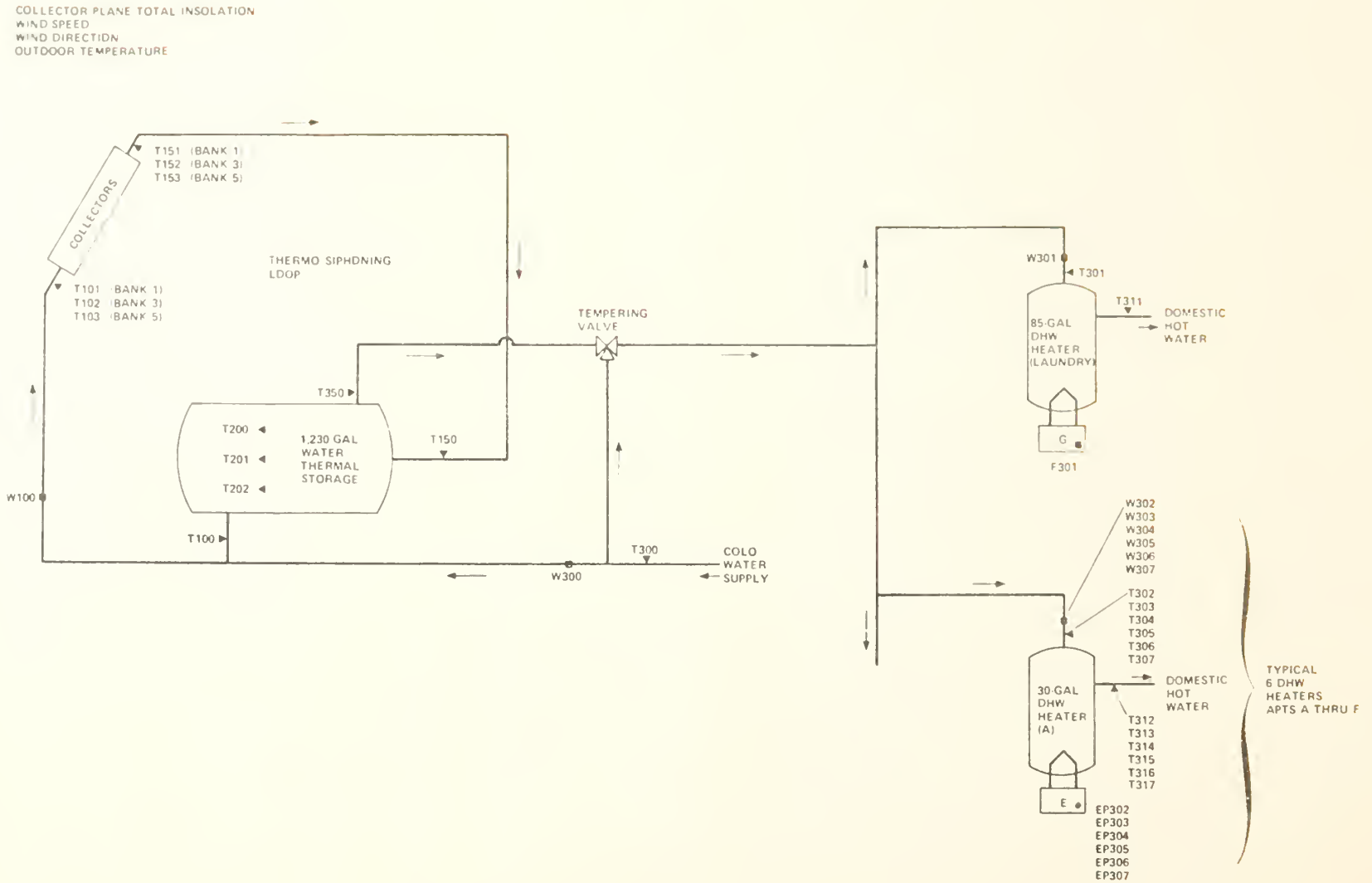

Figure 1. HEI WAI WONG SOLAR ENERGY SYSTEM SCHEMATIC

February of 1620 Btu per square foot for a (south-facing) plane with a tilt of 24 degrees to the horizontal. The average ambient temperature during February was 71°F as compared with the long-term average for February of 72°F.

THERMAL PERFORMANCE

System - During February the solar energy system performed somewhat better than expected. The expected performance was determined from a modified f-chart analysis using measured weather and subsystem loads as inputs. Solar energy collected was 9.2 million Btu versus an estimated 7.6 million Btu. Solar energy used by the system was estimated by assuming that all energy collected would be applied to the load. Actual solar energy used was 8.1 million Btu. System total solar fraction was 78 percent versus an estimated 74 percent.

Collector - The total incident solar radiation on the collector array for the month of February was 30.3 million Btu. During the period the collector loop was operating the total insolation amounted to 30.3 million Btu. The total collected solar energy for the month of February was 9.2 million Btu, resulting in a collector array efficiency of 30 percent, based on total incident insolation. Solar energy delivered from the collector array to storage was 9.2 million Btu. No operating energy was required by the collector loop as this is a thermosiphon collection-to-storage subsystem.

Storage - Solar energy delivered to storage was 9.2 million Btu. There were 8.1 million Btu delivered from storage to the DHW subsystem. Energy loss from storage was 0.77 million Btu. This loss represented 8 percent of the energy delivered to storage. The storage efficiency was 91 percent: This is calculated as the ratio of the sum of the energy removed from storage and the change in stored energy, to the energy delivered to storage. The average storage temperature for the month was 110°F.

DHW Load - The DHW subsystem consumed 8.1 million Btu of solar energy and 2.2 million Btu of auxiliary electrical energy and 0.19 million Btu of fossil fuel energy to satisfy a hot water load of 10.3 million Btu. The solar fraction of this load was 78 percent. No operating energy was required by the DHW subsystem. There was an electrical energy savings of 5.8 million Btu and a fossil fuel energy savings of 3.8 milllion Btu. A daily average of 662 gallons of DHW was consumed at an average temperature of 123°F delivered from the tank.

OBSERVATIONS

The solar energy system operated under a modified configuration. Since February 1 the path of replenishment supply water was not directed to storage, but went through the collector loop first (see Figure 1).

ENERGY SAVINGS

The solar energy system provided a total energy savings of 9.6 million Btu, apportioned into an electrical energy savings of 5.8 million Btu and a fossil fuel energy savings of 3.8 million Btu.

III. ACTION STATUS

No action is required at this time.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: HEI WAI WONG HONOLULU, HAWAII
REPORT PERIOD: FEBRUARY,1979

SOLAR/1014-79/02

SITE/SYSTEM DESCRIPTION:
THE INSTRUMENTED SOLAR ENERGY SYSTEM AT HEI WAI WONG PROVIDES FOR PREHEATING OF DOMESTIC HOT WATER FOR 6 APARTMENT UNITS AND LAUNDRY SERVICE HOT WATER FOR THE 4 STORY APARTMENT COMPLEX.
WATER STORAGE IS LOCATED HIGHER THAN THE SOLAR COLLECTORS. THIS ALLOWS FOR WATER PRESSURE AND THERMOSIPHONING TO TRANSPORT THE WATER THRCUGH THE COLLECTOR/STORAGE CIRCUIT. HOT WATER (DHW AND LAUNDRY SERVICE HW) FLOW TO THE BUILDING IS GRAVITY FED FROM THE ROOFTOP MOUNTED STORAGE TANK.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	30.341	MILLION BTU
	37579	BTU/SQ.FT.
CCLLECTED SOLAR ENERGY	9.211	MILLION BTU
	11408	BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	71	DEGREES F
AVERAGE BUILDING TEMPERATURE	N.A.	DEGREES F
ECSS SOLAR CONVERSION EFFICIENCY	0.27	
ECSS OPERATING ENERGY	N.A.	MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	N.A.	MILLION BTU
TCTAL ENERGY CONSUMED	11.569	MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL	
LOAD	10.34*	N.A.	N.A.	10.349	MILLION BTU
SOLAR FRACTION	78	N.A.	N.A.	78	PERCENT
SCLAR ENERGY USED	8.068	N.A.	N.A.	8.068	MILLION BTU
OPERATING ENERGY	N.A.	N.A.	N.A.	N.A.	MILLION BTU
AUX. THERMAL ENERGY	2.281	N.A.	N.A.	2.281	MILLION BTU
AUX. ELECTRIC FUEL	2.166	N.A.	N.A.	2.166	MILLION BTU
AUX. FOSSIL FUEL	0.192	N.A.	N.A.	0.192	MILLION BTU
ELECTRICAL SAVINGS	5.790	N.A.	N.A.	5.790	MILLION BTU
FOSSIL SAVINGS	3.796	N.A.	N.A.	3.796	MILLION BTU

SYSTEM PERFORMANCE FACTOR: 1.398

* DENOTES UNAVAILABLE DATA
@ DENCTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TC THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: HEI WAI WONG HONOLULU, HAWAII SOLAR/1014-79/02
REPORT PERIOD: FEBRUARY,1979

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GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	32.010 GIGA JOULES
	426744 KJ/SQ.M.
COLLECTED SOLAR ENERGY	9.717 GIGA JOULES
	129546 KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	22 DEGREES C
AVERAGE BUILDING TEMPERATURE	N.A. DEGREES C
ECSS SOLAR CONVERSION EFFICIENCY	0.27
ECSS OPERATING ENERGY	N.A. GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	N.A. GIGA JOULES
TOTAL ENERGY CONSUMED	12.205 GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	10.918	N.A.	N.A.	10.918 GIGA JOULES
SOLAR FRACTION	78	N.A.	N.A.	78 PERCENT
SOLAR ENERGY USED	8.511	N.A.	N.A.	8.511 GIGA JOULES
OPERATING ENERGY	N.A.	N.A.	N.A.	N.A. GIGA JOULES
AUX. THERMAL ENG	2.407	N.A.	N.A.	2.407 GIGA JOULES
AUX. ELECTRIC FUEL	2.285	N.A.	N.A.	2.285 GIGA JOULES
AUX. FOSSIL FUEL	0.203	N.A.	N.A.	0.203 GIGA JOULES
ELECTRICAL SAVINGS	6.108	N.A.	N.A.	6.108 GIGA JOULES
FOSSIL SAVINGS	4.005	N.A.	N.A.	4.005 GIGA JOULES

SYSTEM PERFORMANCE FACTOR: 1.398

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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: HEI WAI WONG HONOLULU, HAWAII
REPORT PERIOD: FEBRUARY,1979

SOLAR/1014-79/02

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	1.830	72	0.363	N	N	N	0.198
2	1.383	73	0.348	O	O	O	0.252
3	1.054	72	0.296	T	T	T	0.281
4	0.937	72	0.336				0.359
5	0.577	67	0.348	A	A	A	0.604
6	1.106	72	0.154	P	P	P	0.139
7	0.600	74	0.226	P	P	P	0.376
8	0.398	73	0.276	L	L	L	0.693
9	0.315	72	0.132	I	I	I	0.418
10	0.718	73	0.176	C	C	C	0.245
11	1.418	68	0.327	A	A	A	0.231
12	1.192	68	0.316	B	B	B	0.265
13	0.833	67	0.292	L	L	L	0.351
14	1.364	68	0.259	E	E	E	0.190
15	1.598	70	0.331				0.207
16	0.527	70	0.339				0.642
17	0.463	72	0.181				0.391
18	0.390	71	0.177				0.454
19	0.677	70	0.197				0.291
20	0.594	71	0.173				0.291
21	1.345	72	0.266				0.197
22	1.329	73	0.373				0.281
23	1.668	73	0.242				0.145
24	1.151	70	0.430				0.374
25	1.791	72	0.387				0.216
26	1.707	73	0.385				0.226
27	1.467	73	0.311				0.212
28	1.910	73	0.426				0.223
SUM	30.341	-	8.068	N.A.	N.A.	N.A.	-
AVG	1.084	71	0.288	N.A.	N.A.	N.A.	0.266
NBS ID	Q001	N113			Q102		N111

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: HEI WAI WONG HONOLULU, HAWAII SOLAR/1014-79/02
REPORT PERIOD: FEBRUARY,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	1.830	1.830	0.768	76	0.420
2	1.383	1.383	0.479	78	0.347
3	1.054	1.054	0.499	78	0.474
4	0.937	0.937	0.283	74	0.303
5	0.577	0.577	0.205	69	0.355
6	1.106	1.106	0.368	*	0.332
7	0.600	0.600	0.120	77	0.200
8	0.398	0.398	0.066	77	0.165
9	0.315	0.315	0.041	73	0.131
10	0.718	0.718	0.165	77	0.230
11	1.418	1.418	0.445	72	0.314
12	1.192	1.192	0.445	70	0.373
13	0.833	0.833	0.360	68	0.433
14	1.364	1.364	0.520	70	0.381
15	1.598	1.598	0.595	74	0.372
16	0.527	0.527	0.123	72	0.233
17	0.463	0.463	0.092	74	0.199
18	0.390	0.390	0.081	72	0.208
19	0.677	0.677	0.166	72	0.245
20	0.594	0.594	0.113	75	0.190
21	1.345	1.345	0.306	74	0.228
22	1.329	1.329	0.319	79	0.240
23	1.668	1.668	0.442	80	0.265
24	1.151	1.151	0.269	72	0.233
25	1.791	1.791	0.521	75	0.291
26	1.707	1.707	0.500	77	0.293
27	1.467	1.467	0.372	74	0.253
28	1.910	1.910	0.548	77	0.287
SUM	30.341	30.341	9.211	-	-
AVG	1.084	1.084	0.329	74	0.304
NBSID	Q001		Q100		N100

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE: HEI WAI WONG HONOLULU, HAWAII SOLAR/1014-79/02
REPORT PERICD: FEBRUARY,1979

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	0.768	0.363	0.188	111	0.718
2	0.479	0.348	0.024	123	0.777
3	0.499	0.296	-0.029	123	0.535
4	0.283	0.336	-0.081	114	0.898
5	0.205	0.348	-0.179	100	0.830
6	0.368	0.154	0.185	101	0.921
7	0.120	0.226	-0.063	109	1.353
8	0.066	0.276	-0.135	99	2.149
9	0.041	0.132	-0.054	88	1.884
10	0.165	0.176	0.080	89	1.547
11	0.445	0.327	0.129	99	1.025
12	0.445	0.316	0.019	108	0.753
13	0.360	0.292	-0.091	105	0.558
14	0.520	0.259	0.086	105	0.663
15	0.595	0.331	0.112	118	0.744
16	0.123	0.339	-0.185	110	1.247
17	0.092	0.181	-0.063	97	1.279
18	0.081	0.177	-0.085	88	1.128
19	0.166	0.197	0.024	87	1.336
20	0.113	0.173	0.021	90	1.724
21	0.306	0.266	0.175	100	1.438
22	0.319	0.373	0.063	113	1.364
23	0.442	0.242	0.219	126	1.043
24	0.269	0.430	-0.187	129	0.904
25	0.521	0.387	0.132	126	0.998
26	0.500	0.385	0.032	136	0.834
27	0.372	0.311	-0.032	137	0.749
28	0.548	0.426	0.028	139	0.828
SUM	9.211	8.068	0.330	-	-
AVG	0.329	0.288	0.012	110	0.912
NBS ID	Q200	Q201	Q202		N108

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
HOT WATER SUBSYSTEM

SITE: HEI WAI WONG HONOLULU, HAWAII
REPORT PERIOD: FEBRUARY,1979

SOLAR/1014-79/02

DAY OF MON.	HOT WATER LOAD MILLION BTU	SOLAR FR.OF LOAD PER CENT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	SUP. WAT. TEMP DEG F	HOT WAT. TEMP DEG F	HOT WATER USED GAL
1	0.449	81	0.363		0.086	0.086	0.000	0.264	0.166	71	120	924
2	0.402	87	0.348		0.054	0.054	0.000	0.249	0.165	72	139	598
3	0.345	86	0.296		0.049	0.049	0.000	0.245	0.086	71	139	517
4	0.399	84	0.336		0.063	0.063	0.000	0.220	0.193	70	129	682
5	0.448	78	0.348		0.099	0.099	0.000	0.241	0.179	70	115	929
6	0.226	68	0.154		0.072	0.072	0.000	0.124	0.051	71	115	428
7	0.295	76	0.226		0.070	0.070	0.000	0.176	0.083	72	121	536
8	0.372	74	0.276		0.096	0.096	0.000	0.233	0.073	71	112	803
9	0.207	63	0.132		0.076	0.076	0.000	0.117	0.025	71	98	593
10	0.302	58	0.176		0.126	0.126	0.000	0.134	0.069	71	98	721
11	0.416	79	0.327		0.089	0.089	0.000	0.197	0.217	70	112	925
12	0.393	80	0.316		0.077	0.077	0.000	0.232	0.139	70	123	698
13	0.368	79	0.292		0.076	0.076	0.000	0.216	0.128	69	118	714
14	0.340	76	0.259		0.081	0.081	0.000	0.171	0.147	69	117	612
15	0.393	84	0.331		0.063	0.063	0.000	0.222	0.181	70	132	597
16	0.380	89	0.339		0.041	0.041	0.000	0.306	0.054	70	132	647
17	0.240	75	0.181		0.059	0.049	0.018	0.162	0.031	70	109	565
18	0.311	57	0.177		0.134	0.102	0.053	0.124	0.088	70	97	764
19	0.414	48	0.197		0.217	0.155	0.104	0.121	0.127	70	96	865
20	0.329	53	0.173		0.156	0.145	0.018	0.153	0.033	71	101	630
21	0.362	73	0.266		0.096	0.096	0.000	0.199	0.112	71	112	626
22	0.445	84	0.373		0.072	0.072	0.000	0.298	0.124	71	129	754
23	0.297	82	0.242		0.054	0.054	0.000	0.203	0.066	75	138	463
24	0.486	89	0.430		0.056	0.056	0.000	0.269	0.269	71	144	703
25	0.450	86	0.387		0.063	0.063	0.000	0.310	0.129	72	142	660
26	0.451	85	0.385		0.066	0.066	0.000	0.264	0.202	72	151	575
27	0.352	88	0.311		0.042	0.042	0.000	0.166	0.242	74	153	464
28	0.474	90	0.426		0.048	0.048	0.000	0.175	0.419	74	157	552
SUM	10.349	-	8.068	N.A.	2.281	2.166	0.192	5.790	3.796	-	-	18545
AVG	0.370	78	0.288	N.A.	0.081	0.077	0.007	0.207	0.136	71	123	662
NBS	Q302	N300	Q300	Q303	Q301	Q305	Q306	Q311	Q313	N305	N307	N308

NOT APPLICABLE

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: HEI WAI WONG HONOLULU, HAWAII
REPORT PERIOD: FEBRUARY,1979

SOLAR/1014-79/02

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	2266	NOT APPLICABLE	72	76	NOT APPLICABLE	238	5
2	1712		73	78		0	2
3	1305		72	78		338	3
4	1160		72	74		0	2
5	714		67	69		0	0
6	1370		72	*		0	2
7	743		74	77		0	1
8	493		73	77		0	0
9	390		72	73		343	2
10	890		73	77		16	2
11	1756		68	72		194	4
12	1476		68	70		220	6
13	1032		67	68		231	4
14	1689		68	70		229	5
15	1979		70	74		236	3
16	653		70	72		249	2
17	573		72	74		242	3
18	483		71	72		250	2
19	838		70	72		288	2
20	736		71	75		294	2
21	1666		72	74		0	1
22	1646		73	79		0	0
23	2066		73	80		218	3
24	1426		70	72		231	4
25	2219		72	75		236	4
26	2114		73	77		222	2
27	1817		73	74		233	3
28	2366		73	77		224	5
SUM	37579	N.A.	-	-	-	-	-
AVG	1342	N.A.	71	74	N.A.	248	3
NBS ID	Q001		N113			N115	N114

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

*U.S. GOVERNMENT PRINTING OFFICE: 1980-640-189/4140. Region 4.